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Advances in Applied Science Research, 2018, 9(2):17-25

ISSN : 0976-8610
CODEN (USA): AASRFC

Palynological and Foraminiferal Biostratigraphic Study of Shale Rocks from Arimogija–Okeluse Area of Ondo State, Southwestern Nigeria

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ABSTRACT

The Biostratigraphy of an exposed section of Arimogija-Okeluse shale of the Araromi Formation, Dahomey Basin sequence was carried out on ten samples. A total of five samples each were used for both foraminiferal and palynological analysis. The analysis was done using modern laboratory tools to conduct comprehensive palynological and foraminiferal studies on all samples. The foraminiferal analysis was carried out in this section for the first time to determine the stratigraphic age and paleoenvironment of deposition of the sequence. The lithologic unit comprises of dark to grey fissile shale. The palynomorphs species is more than the foraminiferal species, but in terms of abundance the forams is more abundant than the palynomorphs. Forty-one palynomorph species comprising Pollen, Spores, Dinoflagellate and Diatom frustules were recovered on analysis. The Palynomorphs species is characterized by diagnostic forms such as, Retidiporites magdalenensis, Cingulatisporites ornatus, Constructipollenites ineffectus, Erecipites sp and Monocolpollenites sphaeroidites. Other important features of the shale section are the relatively high frequency of Monosulcites perspinosus, Hafniasphaera hyalospinosa, spiniferites sp, Laevigatosporites sp and co-occurrence of, Longapertites sp, and Operculodinium sp. The section was also rich in forams. The Benthic arenaceous Foraminifera were abundant and diverse with fourteen benthic species while the planktics and calcareous benthic species are absent due to depositional environment which result in the dearth of the species. The interval is characterized by the co-occurrences of Haplophragmoides excavate, Haplophagmoides hausa, Ammobaculites coprolithiforms, Spiroplectammina dentate, Trochammina sewellensis, Trochammina fibstonensis, Trochammina sp, Ammobaculites sp, Trochammina saheliense, Haplophragmoides sp. All these forms are known to depict Maastrichtian age. However, Middle Maastrichtian age is suggested for Arimogija-Okeluse shale based on the fact that it has features such as acme occurrence of Longapertites marginatus which define Middle Maastrichtian ages. The paleoenvironment of deposition of the Arimogija -Okeluse shale is marginal marine characterized by co-occurrence of dinoflagellate such as Adnatosphaaeridium vittatum, Areoligerasenonensis, spiniferites sp Hafniasphaera hylospinosa. A comprehensive study of Arimogija-Okeluse Shale was carried out by adopting both palynological and foraminiferal biostratigraphic studies so as to establish the stratigraphic age and paleoenvironment of the study area as informed by previous workers.

Keywords: Paleoenvironment, Dinoflagellates, Arimogija, Pollen, Arenaceous, Species

INTRODUCTION

The Benin Embayment is an arcuate coastal basin, onshore parts of which underlie the coastal plains of southwestern Nigeria, Benin, and Togo [1]. A faulted basement high, the Okitipupa Basement Ridge separated the embayment from the Benue Trough until Campanian-Maastrichtian period when subsidence and marine transgression united both basins. It is apparent that some of the basement blocks which underlie the Dahomey Embayment are displaced towards the NNE-SSW basin axis as well as towards the offshore [1].

The studied shale was first termed Arimogija Shale (Abeokuta Formation) by Teme. The outcropping section at Omi Alayo along Arimogija–Okeluse axis situated on Latitude N06°48'32" and Longitude E005°34'26" was selected for this study. Most of the previous geological works around the study area include that of Imeokparia and Onyeobi [2],

Teme, Odeyemi et al. [3], Ola-Buraimo and Adeleye [4]. Since the discovery of tar sand and other mineral deposits in large quantities, particularly Ute Coal Seam and Arimogija-Okeluse Limestone, the region has attracted numerous studies; most of the works involve the occurrence and exploration of coal and limestone. Recent subsurface study has shown that Arimogija shale largely underlie the Arimogija-Okeluse limestone at certain depth around the study area.

No detailed palynological study has been performed on the shale in this area; therefore, the main objective of this study is to determine the relative age of the rock sequence utilizing palynological and foraminifera biostratigraphy of shale rocks of this stratigraphic section.

STUDY AREA

The study area is located in Arimogija-Okeluse, Southwestern Nigeria within longitude $05^{0}34'$E and latitude $06^{0}48'$N with an elevation range between 50 and 80 m. Okeluse is about 5 km south west of Ifon. It is bordered in the north by Ute and in the south by Ogbesse in Edo state which is the boundary between Ondo state and Edo state. The study area is also situated within the eastern part of Dahomey basin; the area is generally accessible by roads as several minor roads and footpaths are evident. The study area is located within the rain forest zone as it is characterized with tall trees and dense grass undergrowth during the rainy season. The area is generally gently dipping and low lying as rivers flow from North to South with most of them seasonal and well drained by River Alayo, a tributary of the Ose discharging directly into the Bight of Benin (Figures 1 and 2).

GEOLOGICAL SETTING OF STUDY AREA

The Araromi Formation overlies the Afowo Formation and is the youngest of the Cretaceous sediment in the eastern Dahomey basin [5]. It is composed of fine to medium grained sandstone at the base overlain by shale and siltstone with an alternating band of limestone, marl, sand and coal towards the top [6]. The shales are light grey to black, lightly fissile, well laminated and mostly marine with high organic content indicating a quiet marine environment of deposition. The Formation is equivalent to upper part Agwu Formation and Nkporoshale [7]. The study area is underlain by cretaceous sediments of Araromi Formation belonging to Abeokuta group in Dahomey basin. The study area (Arimogija-Okeluse environs) is situated south of Owo town in Ondo State, Southwestern Nigeria and with Latitude N06°48'32" and Longitude E005°34'26". The investigated sections of the study area are Imoru, Arimogija and Okeluse communities which are accessible by network of foot-paths, tarred, untarred roads and the Owo-Benin

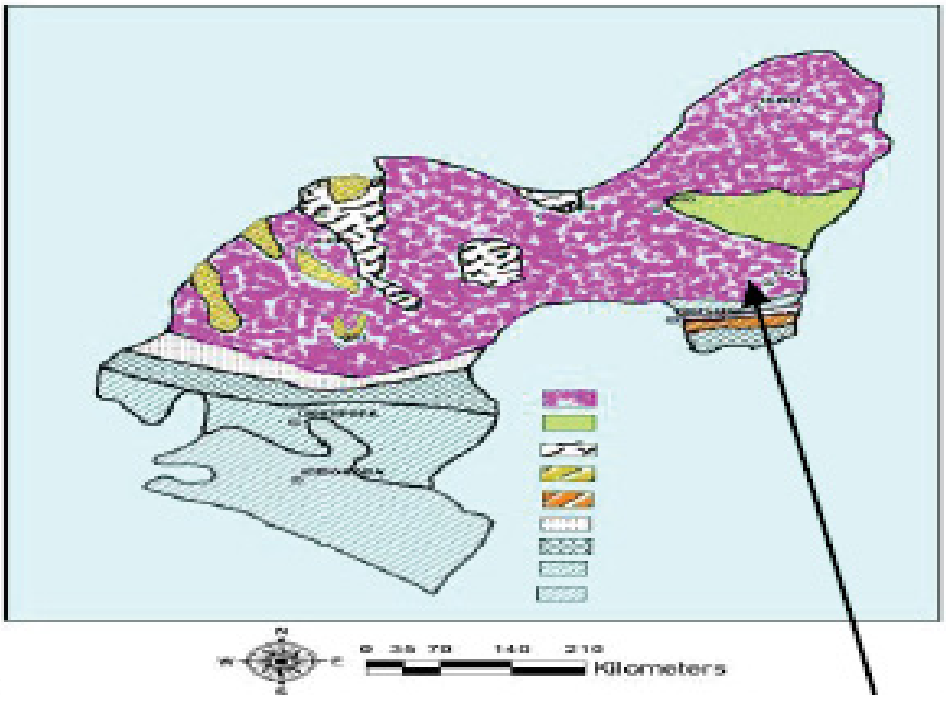

Figure 1: Map of Ondo State Showing the Study Area
(Source: AAUA 2015)

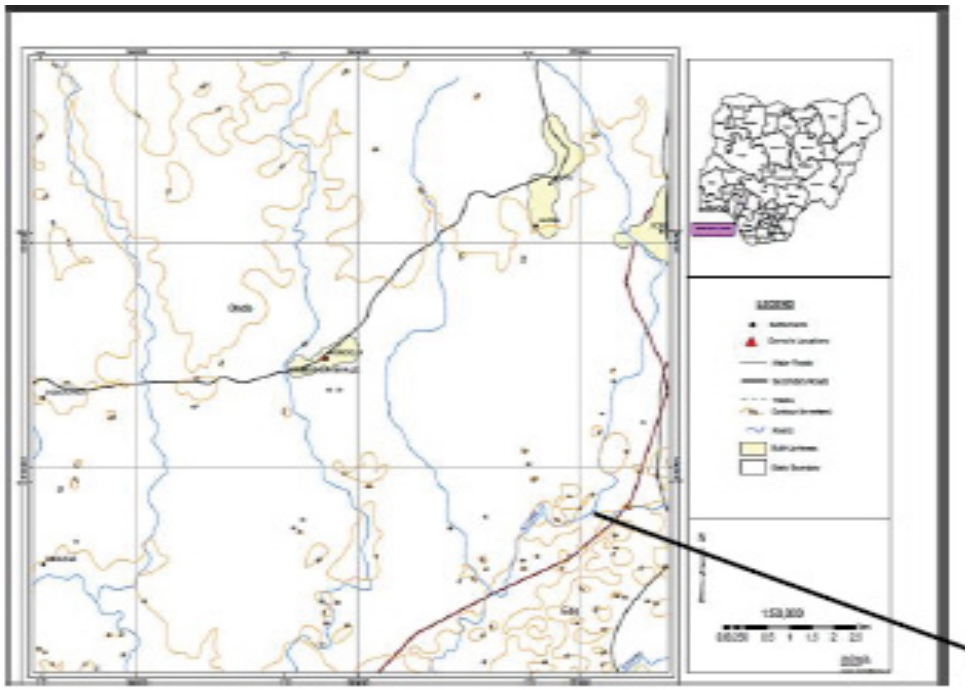

Figure 2: Accessibility map of the study area (Source: Nigeria Geological Survey, 2002).

highway with Sobe, Imoru and Ijagba towns linking them. The lithologic units observed from the exposed section include top soil, brownish, fissile and light grey shale.

Field observation reveals that the basal lithologic unit which is the oldest strata has a shale unit characterized by a dark grey colour, highly fissile and a carbonaceous shale type. Study show that the dark grey colouration depicts an anoxic environment which is a reducing environment. The shale lithology is immediately overlain by sandstone. Observed sandstone is highly ferruginized with minor marl occurrence. Prominent primary structures observed are parallel bedding planes with texture best described as medium grained with a well sorted grain arrangement. Conformably overlying these rock strata is an alternation of carbonaceous shale, clayey siltstone and mica flakes. Inferred paleoenvironment being an anoxic sub-tidal reducing environment. In a younging direction in an upward succession, a sandstone body was observed. This unit is marked by structures described as climbing ripples which were clearly evident at the top. It is highly ferruginized and texture described as being medium grained. Paleoenvironment inferred was that of a tidal flat. The youngest strata depict an alternation of clay and white silt deposition. Some observed sedimentary structures found on the exposure include ripple lamination in the siltstone, massive and consistent planar lamination, parallel and wavy lamination in the siltstone, sole marks and lenticular bedding in the inter-bedded sandstone (Figure 3).

MATERIALS AND METHODS OF STUDY

The major geological earth material used for the purpose of this research is shale. Other materials include sample bags, Global Positioning System, Slides, Conc. HCl, Sieves, Electron Microscope and Canada balsam.

Samples were collected at depth intervals from an exposed lithologic unit in the study area and properly preserved in sample bags with appropriate labels. A total of ten samples of shale rocks were collected and subjected to laboratory analysis. Collected samples were prepared according to standard foraminiferal and palynological procedures. Slides were hitherto prepared to enhance proper identification, counting and photographic documentation of forams and palynomorphs. The textural and compositional characteristics of the lithologic units as observed in-situ were carefully examined and described using a conceptualized lithologic section (Figure 3). The samples were subjected to treatment with hydrochloric acid (HCl) to remove any carbonate. The samples were then thoroughly washed with distilled water after decanting the HCl. The next procedure is the addition of hydrofluoric acid (HF) to the samples to dissolve the silicates. The samples were stirred at regular intervals with a plastic or nickel rod and left overnight in the fume cupboard. Samples were thoroughly washed with water after decanting the HF. The samples were then treated first with warm 36% HCl, and then cold HCl to remove fluoride gels. The samples were then thoroughly washed with distilled water. The next procedure was to wash with 0.5% HCl and then transfer the samples into small 15 cc centrifuge tubes.

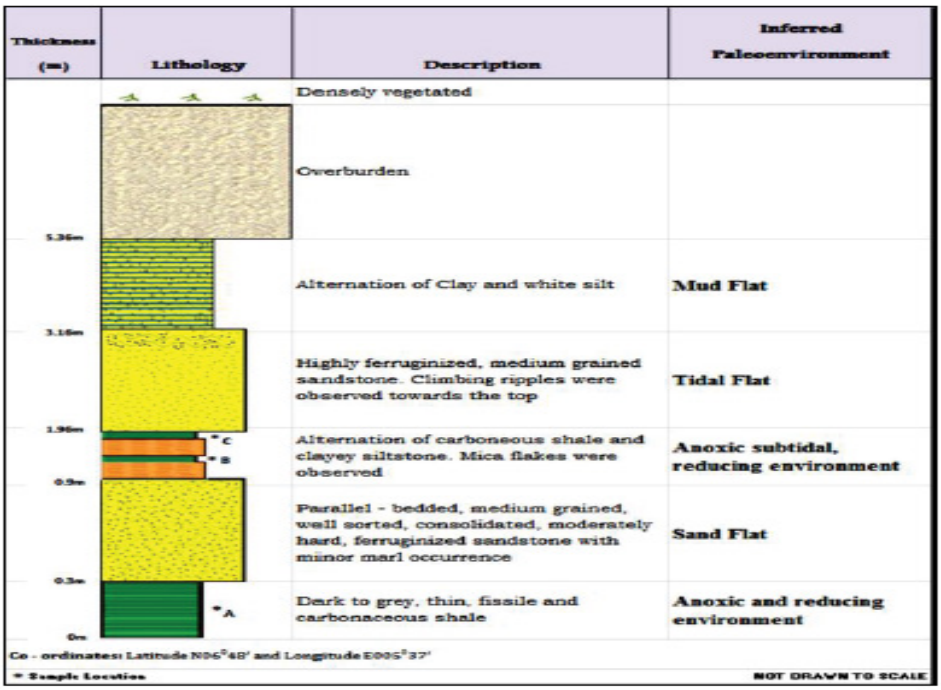

Figure 3: Lithostratigraphic section of the study area.

The 0.5% HCl was decanted after centrifuging and the Zinc bromide (S.G. 2.2) was added and properly stirred with glass rod. After centrifuging, the floating top part consisting of organic material is gently decanted into another tube. Sometimes, Pasteur pipette is used to enhance the decantation process. The organic materials were then thoroughly washed with distilled water. Warm Potassium hydroxide (KOH) was added to the residues and allowed to stand for about 5 minutes. It was centrifuged and the KOH decanted. The residue was washed about 2-3 times with distilled water in order to ensure that all KOH was washed out. The residue was finally washed twice with alcohol. At this point, a sonifier is then utilized to pass the cleaned residue through a five micron sieve. The residues were preserved by adding a drop of glycerol/glycerin to each of the properly labeled phials. They may also be stored in water. A small quantity of glycerin jelly was put in the center of a clean slide and a small quality of organic residue was added and warmed. The mixture was spread out evenly and covered with a cover slip and slide was then labelled.

RESULTS AND DISCUSSIONS

Five outcrop samples from Okeluse-Arimogija were processed for micropaleontological study. Most of the species recorded are mostly arenaceous foraminiferal species; however, these samples were devoid of planktics counterparts. Age designation was therefore interpreted based on the benthic (arenaceous) assemblage encountered in the analyzed samples. The preponderance of arenaceous foraminiferal species over these samples was probably due to the depositional environment or the K/T boundary crisis which affected mostly the planktic and calcareous foraminiferal species. The dominant arenaceous species recorded include *Haplophragmoides excavate, Haplophagmoides hausa, Ammobaculites coprolithiforms, Spiroplectammina dentate, Trochammina sewellensis, Trochammina ribstonensis, Trochammina sp, Ammobaculites sp, Trochammina saheliense, Haplophragmoides sp,* etc (Figure 4).

The results of the five samples subjected to standard laboratory palynological analysis are presented below in the form of distribution charts and shortlisted in the order of palynological assemblages. The prepared samples yielded fair to good recovery of palynomorphs. Some of the palynomorphs are well preserved while few are corroded in nature. The biostratigraphy of the studied section of Arimogija-Okeluse is based on the Spores, Pollen, Dinoflagellates and Diatom frustules from the location in the outcrop section. Some marine palynomorphs (Dinoflagellates) identified are *Spiniferites sp, Adnatosphaeridium vittatum, Hafniasphaera hyalospinosa, Areoligera senonensis, Polysphaeridium complex, Oligosphaeridium cf complex, Deflandra sp, Operculodinium sp, Cleistophaeridium tubiferum, Senegalinium bioavatum* . While major non marine palynomorphs (Pollen and Spores) identified are *Monosulcites perspinosus, Syncolporites marginatus, Laevigatosporites sp, Mauriitidites lehmanii, Longapertites sp, Verrucatosporites sp, Retistephanocolpites williamsi, Longapertites marginatus, Erecipites sp, Cf Liliacidites*

sp, Deltoidospora australis, Retitricolporites sp, Echimorphotriporites trianguliformis, Smilacipites sp, Cyathidites sp, Nyssapollenites pseudocruciatus, Proteacidites lehmanii, cf Constructipollenites ineffectus, Monocolpollenites sphaeroidites, Proteacidites longispinosus, Cingulatisporites ornatus, Ctenolophonidites costatus, Distaverrusporites margaritatus, Syncolporites sp, Mauriitidites crassibaculatus, Proteacidites cf deehani, Reetimonocolpites sp (Figures 5 and 6).

DATA INTERPRETATION

Biozonation

The biozonation of any sedimentary section is dependent on the evolution, extinction and quantitative occurrence of foraminiferal and palynofossils present either at the top or base of the sedimentary section that is of interest. The palynological biostratigraphic investigations can be compared to the work of Jardine and Magloire, Kotova, Lawal and Moullade, the zonal scheme proposed by Jan Muller and the work of Salard-cheboldaeff [8-11]. However, details of the overall foraminiferal and palynofossils are stated depth by depth as shown below:

SAMPLE NUMBER	DEPTH (M)	BASIN	LITHOLGY	FORAMINIFERAL SPECIES																		
				Ammbaculites	Ammbaculites	Haplophragmoid	Ammbaculites	Spiroplectammin	Reophax sp	Trochammina	Trochammina	Haplophragmoid	Trochammina	Arenaceous	Ammbaculites	Haplophragmoid	Trochammina sp	FORAMS ABUNDANCE	PERCENTAGE ABUNDANCE (%)	DIVERSITY	AGE	PALEOENVIRONMENT
5	1.8-2.0			38	4	53	13				15	19		8			2	152	15.3	7		
4	1.3-1.8			4		13	10					2		6				35	3.5	6		
3	0.8-1.3	DAHOMEY	ARIMOGIJA OKELUSE SHALE	71		43	20				10	15		15				174	17.5	6	MAASTRICHTIAN	MARGINALMARINE
2	0.3-0.8			64		27	11			14	10	9		8		2		145	14.5	8		
1	0-0.3			87	14	220	52	2	3	32	21	17	10	23	1		9	491	49.3	13		

Figure 4: Distribution chart for foraminiferal showing abundance, diversity, age and paleoenvironment of arimogija –Okeluse shale of the Araromi Formation, Dahomey Basin.

				POLLEN AND SPORE																												
SAMPLE NUMBER	DEPTH (M)	BASIN	LITHOLOGY	*Monosulcites perspinosus*	*Syncolporites marginatus*	*Laevigatosporites sp*	*Bresinites sp*	*Cf Liliacidites sp*	*Mauritiidites lehmanii*	*Longapertites sp*	*Verrucatosporites sp*	*Retistephanocolpites williamsi*	*Longapertites marginatus*	*Deltoidospora australis*	*Retitricolporites sp*	*Echimorphotriporites trianguliformis*	*Smilacipites sp*	*Cyathidites sp*	*Nyssapollenites pseudocruciatus*	*Proteacidites lehmanii*	*Cf Constructipollenites ineffectus*	*Monocolpollenites sphaeroidites*	*Proteacidite longispinosus*	*Cingulatisporites ornatus*	*Retidiporites magdalenensis*	*Ctenolophonidites costatus*	*Distaverrusporites margaritatus*	*Syncolporites sp*	*Mauritiidites crassibaculatus*	*Proteacidites cf deehani*	*Retimonocolpites sp*	*Echitriporites sp*
5	1.8-2.0					1																									2	
4	1.3-1.8					2												2	2										1	1	1	
3	0.8-1.3	DAHOMEY	ARIMOGIJA OKELUSE SHALE			6	1			6	2		1	3				3	3			2	1	2	1	1	1	1				
2	0.3-0.8						1			2										1	1											
1	0-0.3			4	2	6	7	1	4	4	3	1	4	2	1	1	1	1														

Figure 5: Distribution chart of palynomorph assemblages showing abundance, diversity, age and paleoenvironment of different species of arimogija –Okeluse shale of the Araromi Formation, Dahomey Basin.

				DINOFLAGELLATES										DIATOM FRUSTULE					
SAMPLE NUMBER	DEPTHS (M)	BASIN	LITHOLOGY	Spiniferites sp	Adnatosphaera vittatum	Hafniasphaera hyalospina	Areoligera senonensis	Polysphaeridium complex	Oligosphaeridium cf complex	Deflandrea sp	Operculodinium sp	Cleistosphaeridium tubiferum	Senegalinium bicavatum	Diatom frustule	PALYNOMORPHS ABUNDANCE	PERCENTAGE ABUNDANCE (%)	DIVERSITY	AGE	PALEOENVIRONMENT
5	1.8-2.0													1	2	2.0	4		
4	1.3-1.8														9	6.1	6		
3	0.8-1.3	DAHOMEY	ARIMOGIJA OKELUSE SHALE	8		6						1	1		50	33.8	19	MAASTRICHTIAN	MARGINALMARINE
2	0.3-0.8														5	3.4	4		
1	0-0.3			8	1	7	1	2	5	2	7				89	54.7	25		

Figure 6: Distribution chart of palynomorph assemblages showing abundance, diversity, age and paleoenvironment of arimogija –Okeluse shale of the Araromi Formation, Dahomey Basin.

Biozonation using foraminiferals

Depth 0-0.3 m (AKS/S1): This is the deepest of the section where five samples were taken and the oldest unit of the lithologic section encountered at the study location which justifies the law of superposition. This depth is the richest, as it has the highest occurrence of species abundance of four hundred and ninety one, diversity of thirteen and percentage diversity of 49.3%. The depth is composed of Index fossil such as *Haplophragmoides excavate, Haplophagmoides hausa, Ammobaculites coprolithiforms, Spiroplectammina dentate, Trochammina sewellensis, Trochammina ribstonensis, Trochammina sp, Ammobaculites sp, Trochammina saheliense, Haplophragmoides sp and Arenaceous indeterminate.* Other forms include: *Ammobaculites subcretacea, Spiroplectammina dentate, Reophax sp and Trochammina sp.* This fossil suggest an age not younger than Paleocene and older than Masstrichtian.

Depth 0.3-0.8 m (AKS/S2): With, the occurrence of seven foraminiferal species. This is the depth with the second to the least abundance of species. The maker fossils here include *Ammobaculites coprolithiforms, Haplophragmoides excavate, Haplophagmoides hausa and Trochammina ribstonensis* other forms include: *Haplophragmoides bauchensis, Haplophragmoides sp and Arenaceous indeterminate.* The depth has species abundance of One hundred and thirty one, with diversity of eight and percentage abundance of 14.5%. The fossil suggests a Masstrichtian age.

Depth 0.8-1.3 m (AKS/S3): This is the depth where the 3rd sample was taken. It has a total of seven foraminiferal species. The depth is the second richest depth after the first depth. It has the occurrence of all the fossil found in the first depth except *Ammobaculite sp and Trochammina saheliense.* It has species abundance of One hundred and eighty, with diversity of six and percentage abundance of 17.5%. The fossils here suggest a Maastrichtian age.

Depth 1.3-1.8 m (AKS/S4): This depth is relatively low in foraminiferal abundance, percentage abundance and diversity. Its species abundance is thirty-five, diversity is six and percentage abundance is 3.5%. Index fossil found here include: *Haplophragmoides hausa* and *Haplophragmoides excavate.* Other forms include, *Ammobaculites coprolithiforms, Haplophragmoides sp,* and *Arenaceous indeterminate.* The fossils here suggest Maastrichtian age.

Depth 1.8-2.0 m (AKS/S5): This is the youngest unit of the lithologic section logged at site. Index fossil found here are similar to the one in depth (0.8-1.3 m). Other forms include *Ammobaculites sp, Trochammina sp, and Arenaceous indeterminate.* The depth has species abundance of One hundred and fifty-two, diversity of seven and percentage abundance of 15.3%. The fossil here suggests Maastrichtian age.

Biozonation using palynomorphs

Depth 0-0.3 m (AKS/S1): The depth is extremely rich in palynomorphs. It is characterized by the occurrence of palynomorphs species such as *Cyathidites sp, Longapertites sp, Echimorphotriporites trianguliformis, Deltodospora australis, Longapertites marginatus, Monosulcites perspinosus, Retistephanocolpites williamsi, Erecipites sp, Mauriitidites lehmani, Syncolporites marginatus and* spot occurrence of marine elements such as *Adnatosphaeridium vittatum, Areoligera senonensis, Spiniferites sp, Hafniasphaera hyalospinosa.* The maker fossils include *Spiniferites sp, Erecipites sp, Laevigatosporites sp, Diatom frustules.* The depth has the highest species abundance of eighty-one, highest diversity of twenty-five and highest percentage abundance of 54.7%. The fossil present suggest a Maastrichtian - Paleocene age of deposition.

Depth 0.3-0.8 m (AKS/S2): The depth has species abundance of five, diversity of four and percentage abundance of 6.1%. Majority of the pollen observed from this depth include *Longapertites sp, Proteacidites lehmanii, cf Constructipollenites ineffectus* suggest a Maastrichtian-Paleocene age of deposition.

Depth 0.8-1.3 m (AKS/S3): The depth is relatively rich in palynomorphs. It has a species abundance of fifty, diversity of nineteen and percentage abundance of 33.8%. Index fossil include: *Laevigatosporites sp*, *Longapertites sp*, *Siniferites sp, Hafniasphaera hyalospinosa Oligosphaeridium cf complex*, and *Operculodinium centrocarpum.* The presence of palynomorphs species in sample number AKS/S3 such as *Deltodospora sp, Cingulatisporites ornatus, Monocolpollenites sphaeroidites, Cyathidites sp, Longapertites marginatus Retidiporites magdalenensis, Longapertites sp* and spot occurrence of Dinocyst species such as *Senegalinium bioavatum, Spiniferites sp* suggest a Campanian-Maastrichtian age of deposition.

Depth 1.3-1.8 m (AKS/S4): This depth has palynomorph species abundance of nine, diversity of six and percentage abundance of 6.1%. The depth is characterized by new appearance of *Mauriitidites crassibaculatus* and *Proteacidites cf deehani*. The pollen and spore observed from this depth include *Cyathidites Sp, Retimonocolpites sp, Nyssapollenites psaudocruciatus, Laevigatosporites sp*, and *Cyathidites sp* suggest Maastrichtian-Paleocene age of deposition.

Depth 1.8-2.0 m (AKS/S5): This depth has the least species abundance, diversity and percentage abundance. It

species abundance is three, diversity is four and percentage abundance is 2.0%. The depth is poor in pollen and spore but contain only one pollen and spore species which include *Retimonocolpites sp* and *Laevigatosporite sp* which are poorly fossiliferous. The rarity of palynomorphs might have occurred as a result of weathering and transportation of sediments away from the *insitu* or through erosional truncation.

PALEOENVIRONMENT

The paleoenvironment deduction for the Arimogija - Okeluse Shale is based on the combined Pollen, Spores, Dinoflagellates, and Diatom frustules present in the samples. Preponderance of land-derived miospores which are mainly or having strong affinity with palmae is reported to dwell in transitional environments [12]. On the basis of structural and sculptural features some forms are classified into monocolpate taxa such *as Longapertites spp, Monocolpites marginatus, Monocolpopollenites sp* may suggest deposition in a marginal marine environment [13-18]. However, the presence dinoflagellates such as *Adnatosphaaeridium vittatum, Areoligerasenonensis, spiniferites sp, Hafniasphaerahylospino*sa which are marine element and main marine loving forms as observed in the section may as well suggest influence of fresh water incursion into the marine, thereby given a marginal marine sedimentation.

Thus, it is convenient to suggest that the Arimogija-Okeluse Shale was deposited in a marginal marine setting fairly influenced by fresh water incursion. Micropaleontological characteristics have enhanced the deductions of varying depositional environments over the analyzed interval of samples 1-5. Micropaleontological, Paleoenvironmental deductions were based primarily on benthic foraminiferal assemblage and abundance and diversity of species. Presence or absence of planktic foraminifera also helped in deciphering open ocean environments. The foraminiferal assemblage recorded on these five samples characterized by the abundance of arenaceous foraminiferal species and the rare to non-recovery of planktic and calcareous benthic foraminiferal species over these five samples suggests that the sediments of these samples were deposited in shallow water. This environment is unsuitable for the colonization of planktic foraminiferal species probably as a result of high energy of the environment. A probable Marginal marine environment is suggested. The absence of planktic gives further support to this deduction and affirms a transitional fluvio-marine environment of deposition. Also, the absence of calcareous foraminiferal indicates that it is a marginal marine environment.

CONCLUSION

Biostratigraphic study of the Arimogija-Okeluse shale outcrop was carried out using ten samples of shale rock with five samples each for palynological and foraminiferal analysis. The study covers lithologic description, biostratigraphic, as well as paleo-environmental analysis and age of the sediments.

The foraminiferal analysis was carried out for the first time. The foraminiferal recoveries on these samples are generally good. A total number of fourteen arenaceous (agglutinated) benthic foraminiferal species and nine hundred and ninety seven abundance or species count are recorded from this sample which include *Haplophragmoides excavate, Haplophagmoides hausa, Ammobaculites coprolithiforms, Spiroplectammina dentate, Trochammina sewellensis, Trochammina fibstonensis, Trochammina sp, Ammobaculites sp, Trochammina saheliense, Haplophragmoides sp,* which are the maker fossils used in the determination of the age of the sediment. Other forms include *Arenaceous indeterminate, Ammobaculites subcretacea, and Haplophragmoides bauchensis.* The above foraminiferal species suggests an age not older than Maastrichtian and younger than Paleocene age. Planktic and calcareous benthic species are rare absent because the environment is not suitable for their colonization due to high energy of the environment and this suggest a marginal marine environment.

The palynological analysis reports on the Pollen, Spores, together with Dinoflagellate and Diatom frustules encountered in Arimogija-Okeluse shale. Forty-one palynomorphs species with one hundred and forty eight abundance comprising of Pollen, Spore, Dinoflagellate and Diatom frustules were recorded on analysis. The dating of the outcrop was based on the index pollens, spores, dinoflagellates and diatom frustules.

These include: *Monosulcites perspinosus, Syncolporites marginatus, Laevigatosporites sp, Mauriitidites lehmanii, Longapertites sp, Verrucatosporites sp, Retistephanocolpites williamsi, Longapertites marginatus, Erecipites sp, Cf Liliacidites sp, Deltoidospora australis, Retitricolporites sp, Echimorphotriporites trianguliformis, Smilacipites sp, Cyathidites sp, Nyssapollenites pseudocruciatus, Proteacidites lehmanii, cf Constructipollenites ineffectus, Monocolpollenites sphaeroidites, Proteacidites longispinosus, Spiniferites sp, Adnatosphaeridium vittatum, Hafniasphaera hyalospinosa, Areoligera senonensis, Polysphaeridium complex, Oligosphaeridium cf complex,*

Deflandra sp, Operculodinium sp, Diatom frustules .suggesting a Maastrichtian-Paleocene age.

The main Maastrichtian diagnostic species of pollen and spores include: *Retidiporites magdalenensis, Cingulatisporites ornatus, Periretisyncolpites spp, Constructipollenites ineffectus* and *Monocolpopollenites sphaeroidites*. A critical comparison of the assemblages of forms in this study with that of Lawal and Moullade shows great similarity with the upper part of their zone which contains *Monocolpites marginatus* and *Retidiporites magdalenensis as* this depict Early Maastrichtian age. Since the main forms that characterize Middle Maastrichtian is *Longapertites marginatus* (Ogala et al.) which is present, it is then reasonable to say that the section can be Middle Maastrichtian in age. Thus, Middle Maastrichtian age is suggested for the Arimogija-Okeluse Shale section. The shale is investigated to have been deposited under marginal marine.

ACKNOWLEDGEMENTS

The technical support of Mr. Wale Yussuph, Director and a Senior Geologist with Earthprobe Laboratory located in Lagos is highly appreciated and acknowledged for making facilities available for this research. Much thanks to Samuel Morounmubo and some others who actively participated in the fieldwork making this research a huge success.

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